

ASHRAE 2012 Winter Meeting

ASHRAE Standard 90.1 Committee

January 22, 2012

Chicago, Illinois



U.S. Department of Energy
Energy Efficiency and Renewable Energy

Achieving 50% Energy Saving Goal

90.1-2013 Progress Indicator Report

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Team Lead, Building Energy Codes R&D

Topics

- ▶ 90.1 Progress Indicator
- ▶ 90.1-2013 Addenda
- ▶ Energy and Cost Saving Results
- ▶ 50% Concept Ideas and Energy Savings

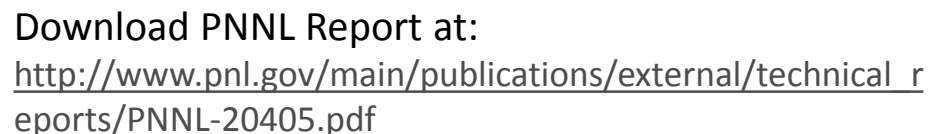
90.1 Progress Indicator

90.1 Progress Indicator

- ▶ Support 90.1-2013 Energy Cost Saving Targets
 - Regulated Loads only: 50% target includes only regulated energy end-use loads as included in the 90.1-2004 baseline.
 - Whole building: 40% target which includes all energy end-uses.
- ▶ Use Progress Indicator to measure development progress in Standard 90.1-2013
- ▶ Update PI and report to SSPC 90.1 regularly
 - January 2012
 - June 2012
 - October 2012

- Progress Indicator methodology and prototype building models are documented in PNNL's published report

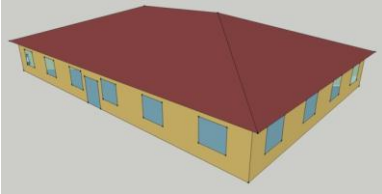
- 16 prototype buildings
- 17 climate locations
- 90.1-2004, 90.1-2007 and 90.1-2010 code-compliant models
- Scorecards (building basic modeling information)
- National aggregated site energy savings results
- EnergyPlus weather files



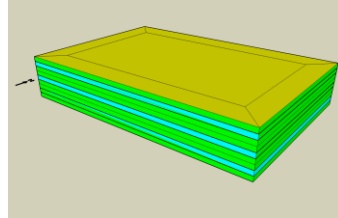
Pacific Northwest
NATIONAL LABORATORY

Prototype Building Models

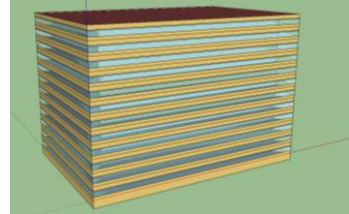
Small Office



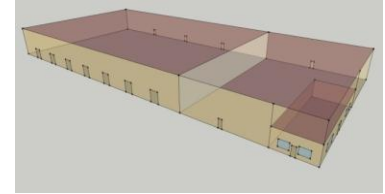
Medium Office



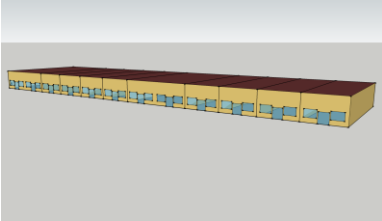
Large Office



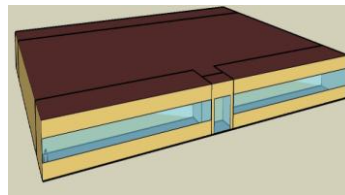
Warehouse



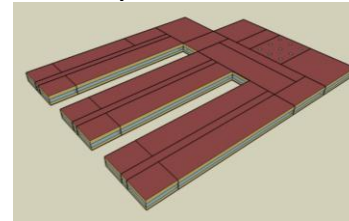
Strip Mall Retail



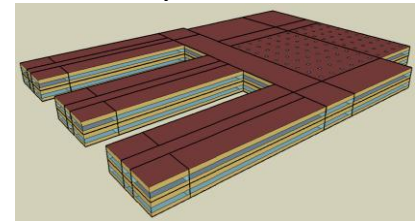
Standalone Retail



Primary School



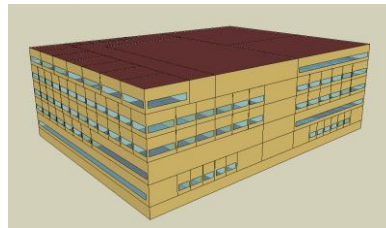
Secondary School



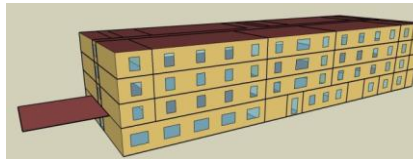
Outpatient Healthcare



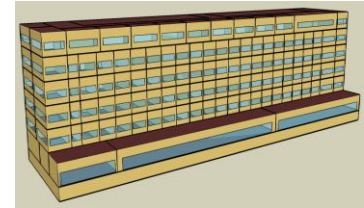
Hospital



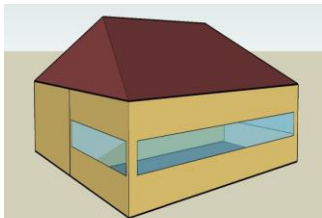
Small Hotel



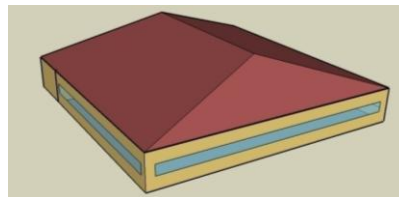
Large Hotel



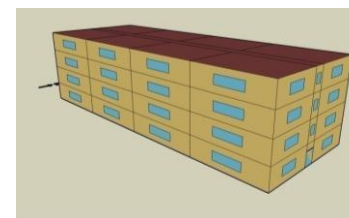
Quick-service Restaurant



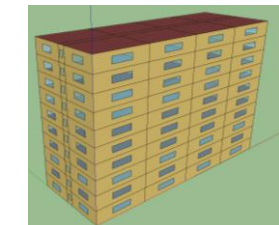
Full-service Restaurant



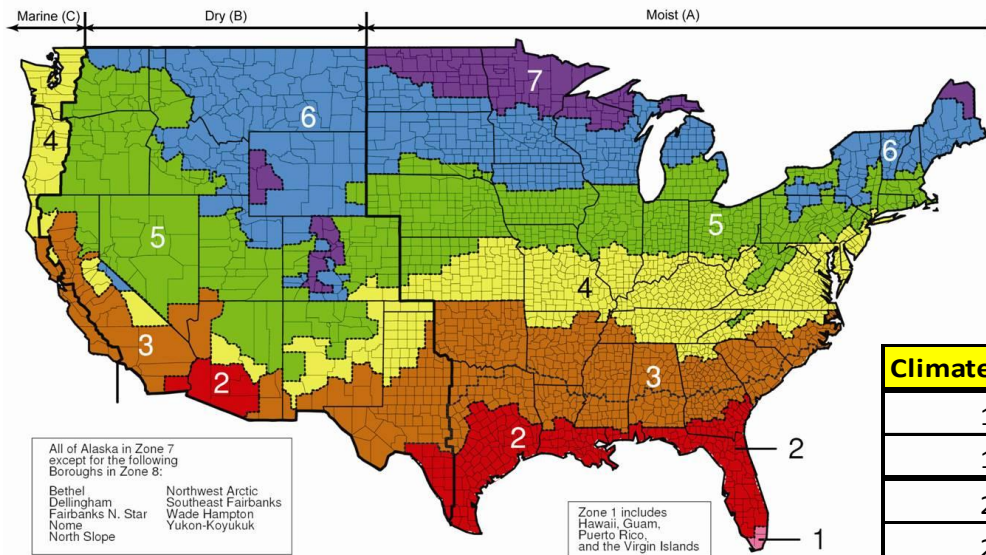
Mid-rise Apartment



High-rise Apartment



Climate Zones and Locations



Climate Zone	Climate Zone Type	Representative City
1A	Very Hot - Humid	Miami FL
1B	Very Hot - Dry	Riyadh, Saudi Arabia
2A	Hot - Humid	Houston, TX
2B	Hot - Dry	Phoenix AZ
3A	Warm - Humid	Memphis, TN
3B	Warm - Dry	El Paso, TX
3C	Warm - Marine	San Francisco, CA
4A	Mixed - Humid	Baltimore, MD
4B	Mixed - Dry	Albuquerque NM
4C	Mixed - Marine	Salem OR
5A	Cool - Humid	Chicago IL
5B	Cool - Dry	Boise ID
5C	Cool - Marine	Vancouver, BC
6A	Cool - Humid	Burlington VT
6B	Cool - Dry	Helena MT
7	Very Cold	Duluth, MN
8	Subarctic	Fairbanks, AK

New Construction Weighting Factors

Download PNNL report on new construction weights at:

http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19116.pdf

	1	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	6A	6B	7	8	weights by bldg type
Large office	0.102	0.326	0.061	0.445	0.285	0.117	1.132	0.000	0.154	0.442	0.121	0.133	0.000	0.011	0.000	3.33
Medium office	0.129	0.813	0.292	0.766	0.715	0.136	1.190	0.036	0.196	1.060	0.342	0.298	0.035	0.033	0.007	6.05
Small office	0.084	1.064	0.289	0.963	0.475	0.078	0.936	0.047	0.123	0.920	0.322	0.241	0.030	0.032	0.005	5.61
Standalone retail	0.224	2.220	0.507	2.386	1.250	0.191	2.545	0.119	0.428	3.429	0.792	0.948	0.091	0.109	0.014	15.25
Strip mall retail	0.137	0.991	0.254	1.021	0.626	0.103	1.008	0.023	0.107	1.023	0.201	0.153	0.016	0.007	0.001	5.67
Primary school	0.064	0.933	0.164	0.944	0.446	0.048	0.895	0.030	0.094	0.920	0.224	0.168	0.037	0.023	0.003	4.99
Secondary school	0.160	1.523	0.230	1.893	0.819	0.109	2.013	0.063	0.243	2.282	0.438	0.415	0.086	0.075	0.012	10.36
Hospital	0.040	0.479	0.096	0.468	0.273	0.039	0.615	0.022	0.106	0.812	0.218	0.221	0.024	0.034	0.001	3.45
Outpatient health care	0.037	0.567	0.134	0.581	0.275	0.061	0.818	0.023	0.181	1.058	0.218	0.342	0.033	0.039	0.002	4.37
Full-service restaurant	0.009	0.106	0.025	0.111	0.047	0.006	0.127	0.006	0.010	0.143	0.031	0.031	0.004	0.004	0.000	0.66
Quick-service restaurant	0.008	0.092	0.020	0.102	0.063	0.007	0.089	0.005	0.014	0.128	0.026	0.025	0.003	0.004	0.000	0.59
Large hotel	0.109	0.621	0.125	0.635	0.793	0.106	0.958	0.037	0.123	0.919	0.200	0.227	0.058	0.038	0.004	4.95
Small hotel	0.010	0.288	0.030	0.268	0.114	0.022	0.315	0.020	0.039	0.365	0.089	0.107	0.031	0.020	0.004	1.72
Warehouse	0.349	2.590	0.580	2.966	2.298	0.154	2.446	0.068	0.435	3.580	0.688	0.466	0.049	0.043	0.002	16.72
High-rise apartment	1.521	1.512	0.076	0.652	0.741	0.173	2.506	0.000	0.358	1.163	0.115	0.125	0.016	0.008	0.000	8.97
Mid-rise apartment	0.257	1.094	0.093	0.825	0.862	0.260	1.694	0.022	0.371	1.122	0.318	0.313	0.056	0.032	0.000	7.32
weights by zone	3.24	15.22	2.98	15.03	10.08	1.61	19.29	0.52	2.98	19.37	4.34	4.21	0.57	0.51	0.06	100.00

90.1 Progress Indicator

- ▶ 90.1-2010 Simulation Working Group previously oversaw the prototype models used for the 90.1-2010 Progress Indicator analysis
- ▶ Now Advanced Energy Standards (AES) Working Group
 - Represent the 90.1 subcommittees
 - Represent the WG75 from the 189.1 committee
 - Oversee PNNL's Progress Indicator analysis
 - Provide guidance or recommendations on Appendix H in 90.1-2013 Work Plan

90.1 Progress Indicator

Prototype Models Enhancements

- ▶ PNNL commits to maintain and continuously enhance the prototype buildings models
- ▶ AES WG has solicited review comments from 90.1 subcommittees on PNNL-published prototype models
- ▶ AES WG approved the following changes
 - Revise the window-to-wall ratio (WWR) in mid-rise and high-rise apartments
 - Add data center/IT closets into the large office building model
 - Review service hot water loads in all prototype models
 - Create a grocery store model to analyze possible addenda, but the grocery store model will not be rolled into the progress indicator framework.

90.1-2013 Addenda Summary

New Addenda since Publication of 90.1-2010

bz	Bldg. electric loads metering	k	Low-voltage dry-type transformers
cg	ECB – daylighting modeling	l	Fan power limitation corrections
ci	ECB – cooling towers	m	Lighting alterations controls
ds	Daylighting terms definitions	n	Elevator cab lighting clarification
a	Motor efficiency reference	o	Glazed sectional garage door
b	Escalators automatically slow	p	Cool roof reference of CRRC
c	ECB - HVAC lab exhaust	q	Fenestration labeling clarification
e	ECB - existing bldg. baseline	s	Static pressure sensor location
g	Commercial refrigeration equip.	v	Receptacle controls clarification
h	Water-to-air heat pump efficiency	y	Small electric motor efficiency
j	Table 6.8.1 corrections	z	Water economizer relocations

	Approved by ASHRAE BOD for publication
	Ready for ASHRAE BOD approval for publication at January 2012 meeting

90.1-2013: Jan2012 Progress Indicator

22 addenda

- Total addenda evaluated compared with 90.1-2010

18 addenda

- In Section 5-10 (mandatory and prescriptive requirements)

5 addenda

- Have energy saving impacts

2 addenda

- Can quantify energy savings and were captured in PI

Addenda to 90.1-2010

Addendum	Captured Energy Savings in PI	Description
B	No	Requires escalators and moving walks to automatically slow when not conveying passengers. The corresponding reference has also been added.
G	Yes	Adds efficiency requirements for commercial refrigerators, freezers and refrigeration equipment. Table 6.8.1L and Table 6.8.1M have been added which specify the energy use limits for refrigerators and freezers. The corresponding references have also been added in Chapter 12.
H	Yes	Modifies the minimum efficiency standards for water to air heat pumps (water loop, ground water and ground loop). The proposed cooling EERs and heating COPs are more stringent than the present values. This addendum also removes the small duct high velocity product class from Table 6.8.1B.
M	No	Adds some control requirements for lighting alterations, for interior and exterior applications. It adds a section for submittals and includes loading docks as a tradable surface. It modifies the provisions for additional interior lighting power, which would now be calculated on the basis of controlled wattage.
O	No	Adds the definition for sectional garage doors. Fenestration air leakage provisions are also updated to include requirements for glazed sectional garage doors.

90.1-2013 Jan2012 PI
Energy and Cost Saving Results

90.1-2013 Jan2012 PI

Energy Savings – Whole Building

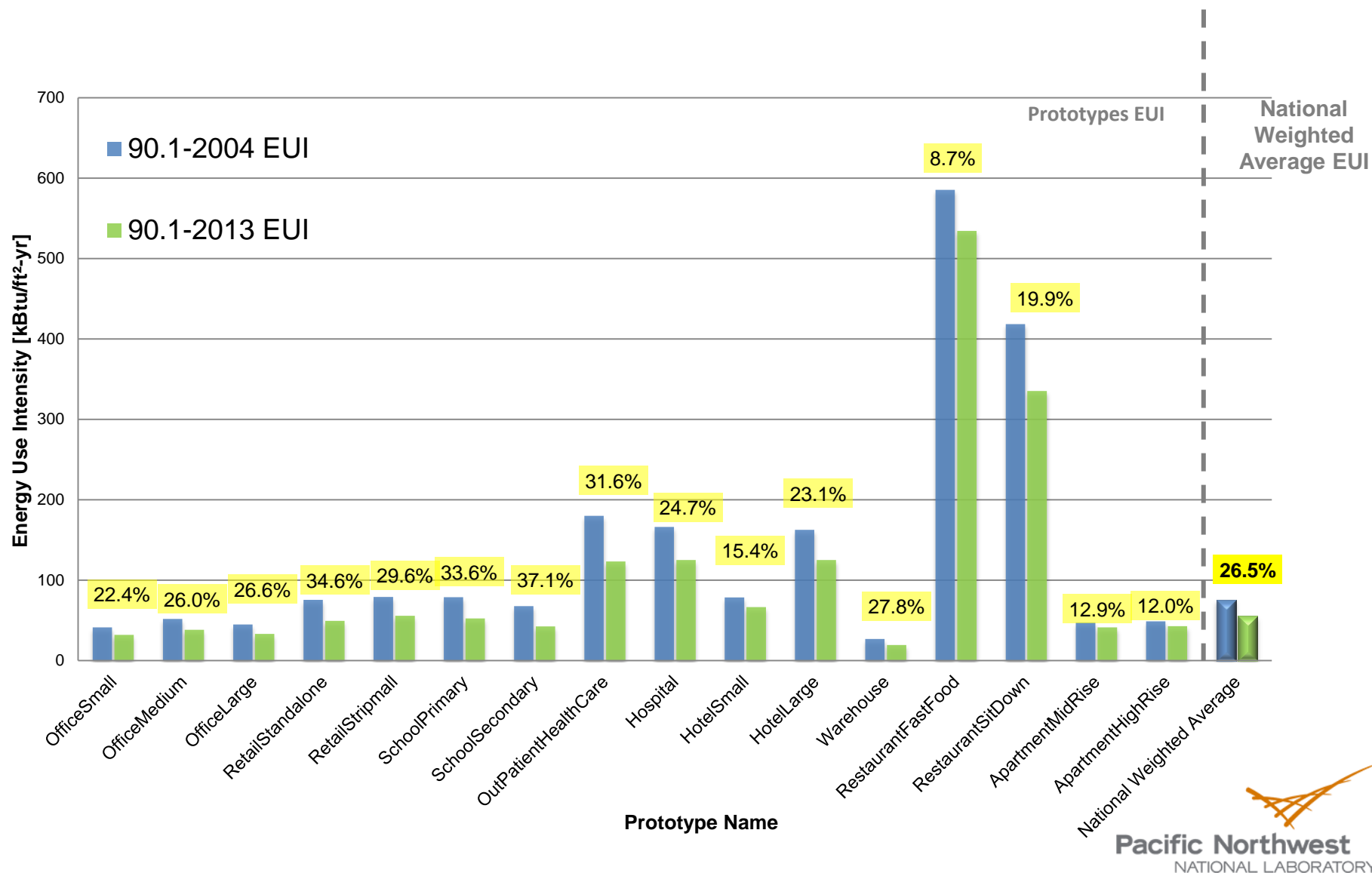
Building Type	Prototype	Site Energy [kBtu/ft ² -yr]			% Energy Savings	
		90.1-2004	90.1-2010	90.1-2013	90.1-2010 vs. 90.1-2004	90.1-2013 vs. 90.1-2004
Office	Small office	41.1	31.9	31.9	22.4%	22.4%
	Medium office	51.6	38.2	38.2	26.0%	26.0%
	Large office	44.8	32.9	32.9	26.6%	26.6%
Retail	Standalone retail	75.2	49.2	49.2	34.6%	34.6%
	Strip mall	78.9	55.5	55.5	29.6%	29.6%
Education	Primary school	78.7	52.4	52.2	33.4%	33.6%
	Secondary school	67.5	42.5	42.4	37.0%	37.1%
Health Care	Outpatient healthcare	179.8	122.9	122.9	31.6%	31.6%
	Hospital	165.9	125.0	124.9	24.7%	24.7%
Lodging	Small hotel	78.3	66.3	66.3	15.4%	15.4%
	Large hotel	162.3	124.8	124.8	23.1%	23.1%
Warehouse	Warehouse	26.6	19.2	19.2	27.8%	27.8%
Food Service	Quick-service restaurant	585.2	539.6	534.3	7.8%	8.7%
	Full-service restaurant	418.4	337.2	335.1	19.4%	19.9%
Apartment	Mid-rise apartment	47.2	41.1	41.1	12.9%	12.9%
	High-rise apartment	48.5	43.3	42.7	10.7%	12.0%
National-weighted average		75.2	55.4	55.2	26.4%	26.5%

90.1-2013 Jan2012 PI

Energy Cost Savings – Whole Building

Building Type	Prototype	Energy Cost [\$/ft ² -yr]			% Energy Cost Savings	
		90.1-2004	90.1-2010	90.1-2013	90.1-2010 vs. 90.1-2004	90.1-2013 vs. 90.1-2004
Office	Small office	\$1.17	\$0.91	\$0.91	22.2%	22.2%
	Medium office	\$1.43	\$1.04	\$1.04	27.1%	27.1%
	Large office	\$1.18	\$0.91	\$0.91	23.3%	23.3%
Retail	Standalone retail	\$1.89	\$1.32	\$1.32	29.9%	29.9%
	Strip mall	\$1.96	\$1.41	\$1.41	28.0%	28.0%
Education	Primary school	\$1.88	\$1.37	\$1.37	27.0%	27.3%
	Secondary school	\$1.69	\$1.15	\$1.15	31.8%	32.0%
Health Care	Outpatient healthcare	\$4.38	\$3.15	\$3.15	28.1%	28.1%
	Hospital	\$3.79	\$3.01	\$3.01	20.4%	20.5%
Lodging	Small hotel	\$1.72	\$1.47	\$1.47	14.6%	14.6%
	Large hotel	\$2.98	\$2.42	\$2.42	18.7%	18.8%
Warehouse	Warehouse	\$0.58	\$0.42	\$0.42	27.5%	27.5%
Food Service	Quick-service restaurant	\$10.71	\$9.70	\$9.55	9.5%	10.9%
	Full-service restaurant	\$8.25	\$6.36	\$6.30	22.9%	23.7%
Apartment	Mid-rise apartment	\$1.24	\$1.11	\$1.11	10.4%	10.4%
	High-rise apartment	\$1.34	\$1.23	\$1.21	7.9%	9.4%
National-weighted average		\$1.78	\$1.36	\$1.36	23.6%	23.9%

90.1-2013 Jan2012 PI Whole Building Energy Saving Results



90.1-2013 Jan2012 PI Energy Savings – Regulated Loads Only

Building Type	Prototype	Site Energy [kBtu/ft ² /yr]			% Energy Savings	
		90.1-2004	90.1-2010	90.1-2013	90.1-2010 vs. 90.1-2004	90.1-2013 vs. 90.1-2004
Office	Small office	32.0	23.4	23.4	26.7%	26.7%
	Medium office	36.6	24.7	24.7	32.4%	32.4%
	Large office	29.3	18.9	18.9	35.7%	35.7%
Retail	Standalone retail	67.7	41.7	41.7	38.4%	38.4%
	Strip mall	73.5	50.1	50.1	31.8%	31.8%
Education	Primary school	56.6	30.7	30.7	45.8%	45.8%
	Secondary school	52.8	28.2	28.2	46.6%	46.6%
Health Care	Outpatient healthcare	132.6	76.5	76.5	42.3%	42.3%
	Hospital	116.3	75.8	75.8	34.8%	34.8%
Lodging	Small hotel	55.9	44.0	44.0	21.2%	21.2%
	Large hotel	126.6	89.6	89.6	29.3%	29.3%
Warehouse	Warehouse	24.1	16.8	16.8	30.3%	30.3%
Food Service	Quick-service restaurant	299.4	253.9	252.7	15.2%	15.6%
	Full-service restaurant	257.6	176.9	176.7	31.3%	31.4%
Apartment	Mid-rise apartment	32.7	26.8	26.8	18.1%	18.1%
	High-rise apartment	35.3	30.4	29.7	14.0%	15.8%
National-weighted average		57.9	38.4	38.3	33.6%	33.8%

90.1-2013 Jan2012 PI

Energy Cost Savings – Regulated Loads Only

Building Type	Prototype	Energy Cost [\$/ft ² /yr]			% Energy Cost Savings	
		90.1-2004	90.1-2010	90.1-2013	90.1-2010 vs. 90.1-2004	90.1-2013 vs. 90.1-2004
Office	Small office	\$0.90	\$0.64	\$0.64	29.0%	29.0%
	Medium office	\$0.99	\$0.60	\$0.60	39.0%	39.0%
	Large office	\$0.83	\$0.56	\$0.56	33.0%	33.0%
Retail	Standalone retail	\$1.66	\$1.10	\$1.10	33.9%	33.9%
	Strip mall	\$1.80	\$1.25	\$1.25	30.6%	30.6%
Education	Primary school	\$1.37	\$0.86	\$0.86	37.0%	37.4%
	Secondary school	\$1.34	\$0.80	\$0.80	40.3%	40.5%
Health Care	Outpatient healthcare	\$3.09	\$1.86	\$1.86	39.9%	39.9%
	Hospital	\$2.94	\$2.17	\$2.16	26.3%	26.4%
Lodging	Small hotel	\$1.32	\$1.07	\$1.07	19.0%	19.0%
	Large hotel	\$2.57	\$2.01	\$2.01	21.8%	21.8%
Warehouse	Warehouse	\$0.50	\$0.34	\$0.34	31.7%	31.7%
Food Service	Quick-service restaurant	\$7.54	\$6.52	\$6.38	13.5%	15.5%
	Full-service restaurant	\$5.83	\$3.95	\$3.88	32.3%	33.4%
Apartment	Mid-rise apartment	\$0.80	\$0.67	\$0.67	16.1%	16.1%
	High-rise apartment	\$0.95	\$0.85	\$0.83	11.2%	13.3%
National-weighted average		\$1.40	\$0.97	\$0.97	30.2%	30.5%

Concept Ideas for Achieving 50% Energy Saving Goal

50% Concept Ideas Envelope and Lighting Concepts

A total of 34 concept ideas that PNNL has presented to 90.1 subcommittees at 2011 June Montreal Meeting

ENV 1	Comprehensive Envelope Overhaul
ENV 2	Eliminate Semi-Heated Space Type
ENV 3	Minimization of Number of Envelope Categories
ENV 4	Expanded Cool Roof Requirements
ENV 5	Reduce Whole Building Air Leakage
ENV 6	Vestibule Simplification and Clarification
LTG 1	Automatic interior lighting shut off
LTG 2	Lower LPDs in selected spaces
LTG 3	Full Daylight Application
LTG 4	Night Light Shutoff
LTG 5	Reduce Lighting Exemptions
LTG 6	Full Daylight Design

Concept ideas are under the analysis and development by 90.1 subcommittees and/or PNNL

50% Concept Ideas (cont'd)

Mechanical & Performance Concepts

MECH 1	Single Zone VAV Application	MECH 13	Cooling Tower Controls
MECH 2	DX Unit Heat Pump Requirement	MECH 14	Cooling Tower Efficiency
MECH 3	Packaged Terminal Unit Heat Pump Requirement	MECH 15	Limit Use of Air-Cooled Above Threshold Cooling Peak Load
MECH 4	Terminal Box Minimum Air Flow Optimization	MECH 16	Water Side Economizers for Non-Fan Cooling Systems
MECH 5	High Efficiency Motors in Fan Powered Terminal Units	MECH 17	Heat Recovery From Condenser Heat
MECH 6	Separate Air Temperature Control for Perimeter and Core Zones	MECH 18	Mechanical Equipment Efficiency
MECH 7	Occupant Based HVAC Space Control	MECH 19	Refrigeration Equipment Efficiency
MECH 8	Energy Recovery Requirement Thresholds	MECH 20	Humidity Control
MECH 9	Increase Energy Recovery Minimum Effectiveness	MECH 21	Alternative Service Water Heating Sources
MECH 10	Enhanced Requirements for Demand Controlled Ventilation	PERF 1	50% Whole Building Performance Approach
MECH 11	Fan Efficiency		
MECH 12	Fan Power Reduction		

Summary of Individual Concept Savings

Concept	% Savings Regulated Loads Only	% Savings Whole Building Loads
ENV 1 Comprehensive Envelope Overhaul	5.0%	3.7%
ENV 3 Minimization of Number of Envelope Categories	7.4%	5.4%
ENV 4 Expanded Cool Roof Requirements	1.0%	0.7%
ENV 5 Reduce Whole Building Air Leakage	1.6%	1.2%
LTG 1 Automatic Interior Lighting Shutoff	5.2%	3.8%
LTG 2 Lower LPDs in Selected Spaces	2.0%	1.5%
LTG 3 Full Daylight Application	0.2%	0.1%
LTG 4 Night Light Shutoff (merged with LTG1)	-	-
LTG 6 Enhanced Top Lighting	0.7%	0.5%
MECH 1 Single Zone VAV Application	2.0%	1.5%
MECH 3 Packaged Terminal Heat Pump Requirement	0.3%	0.2%
MECH 7 Occupant Based HVAC Space Control	1.0%	0.8%
MECH 8 Energy Recovery Requirement Thresholds	1.6%	1.2%
MECH 10 Enhanced Demand Controlled Ventilation	0.5%	0.3%
MECH 12 Fan Power Reduction	1.5%	1.1%
MECH 14 Cooling Tower Efficiency	0.1%	0.04%
MECH 18 Mechanical Equipment Efficiency	2.4%	1.7%
MECH 21 Alternative SWH Sources	1.9%	1.4%

Summary of Package Savings

	% Savings Regulated Loads Only		% Savings Whole Building Loads	
	Baseline 2004	Baseline 2010	Baseline 2004	Baseline 2010
Envelope Package		9.4%		6.9%
Lighting Package		7.3%		5.3%
Mechanical Package		12.3%		9.1%
Interactive Package (Env+Ltg+Mech)	53.2%	29.0%	43.2%	21.3%

Acknowledgements

DOE Building Energy Codes Program

Michael Erbesfeld, Project Manager

Advanced Energy Standards WG

Drake Erbe, Bing Liu, Dick Lord, Susanna Hanson

Michael Lane, Michael Mehl, Jason Glazer, Mike Rosenberg

Merle McBride, Michael Waite, Ron Burton, Molly McGuire

PNNL's Building Simulation Team

Bing Liu, team lead

Mike Rosenberg, Brian Thornton

Dr. Weimin Wang, Dr. Yulong Xie

Dr. Heejin Cho, Dr. Jian Zhang

Rahul Athalye, Vrushali Mendon, Hung Ng



Backup Slides

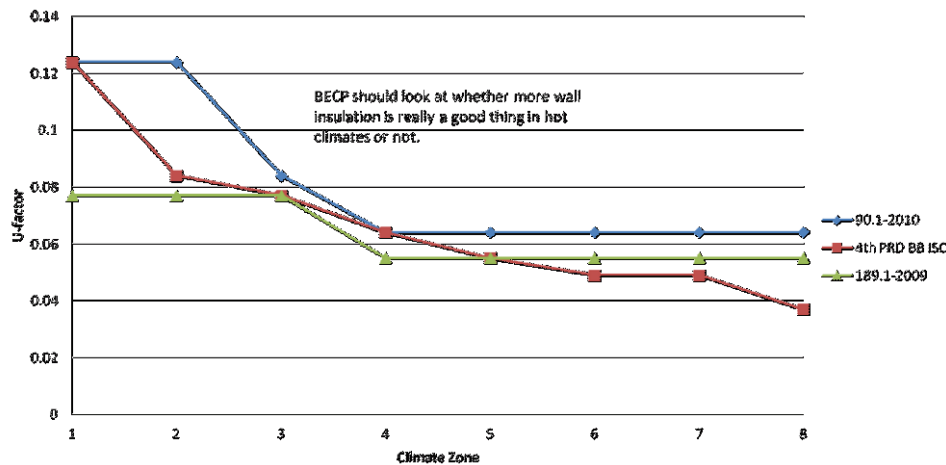
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Addendum bb

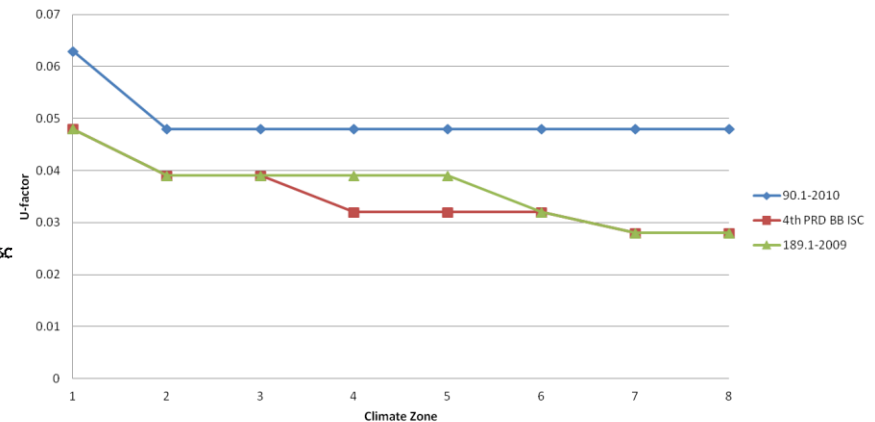
Improved Opaque and Fenestration Performance

ENV1. Comprehensive Update of Prescriptive Envelope Requirements (4th ISC Addenda bb)

Steel Framed Walls



Roof with Insulation Above Deck



Addendum bb Energy Saving Impacts

